The 12th at Night theſe Lights are ſaid to have appeared again, as alſo on *Saturday* the 18th, to a very great degree, but I ſaw them not; the Weather ſtill froſty with little Snow.

Feb. 22. At Night. Hard Snow.

23, 27. A Thaw and ſome Rain, and but little Froſt afterwards, only dry cold Winds, till the 27th, when the Froſt returned very ſharp, with exceeding cold Winds, at N. E. and S. E. for a Fortnight or more, without any Snow, and did a great deal of hurt.

VII. *Obſervations on the Muſcular Fibres of Fiſh.* *By Mr.* Leeuwenhoeck, F. R. S.

Delft, April 11. 1721.

IN my Letter to this Honourable Society of the 24th of *January* laſt, I treated of the great Number of Veſſels that I had obſerved in the Fibres of the Muſcles. I now take the liberty of preſenting you with the following Obſervations, hoping there may be ſomething in them for your Entertainment.

It has been affirmed to me by ſeveral Perſons, and in particular, by a certain very learned Foreigner, that Nature, in all her various Productions, conſtantly obſerves the ſame Courſe and Manner of Operation. To this Aſſertion my Obſervations do by no means agree; neither thoſe, that I have made upon the Generation

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neration of Animals, and the Seeds of Plants; nor yet thoſe that I have made upon the Muſcles and Muſcular Fibres of different Animals, foraſmuch as the Muſcles of Fiſhes are not provided with any Tendons. On this occaſion, I have lately examin'd anew the Muſcles of the Cod-fiſh, upon which I have made the following Obſervations.

After the late Diſcoveries I had made of the ſmall Veſſels in the Muſcular Fibres of the Whale, the Ox, the Sheep, and the Mouſe, I was apt to imagine, that the ſame Fabrick would hold in the Muſcular Fibres of Fiſh likewiſe: but as this could not be certainly concluded, having at that time in my houſe a part of a freſh Cod, I cut off a piece of the Fiſh, with Intent to examine it with my Microſcope ſome Days afterward.

This piece of Fiſh I cut into ſmall Slices, ſome according to the length of the Fibres, and others directly acroſs them, in order to obſerve, whether theſe Muſcular Fibres were compoſed of great Numbers of ſmall Veſſels running according to the length of the Fibre. And in effect I found, that, when I had cut the Fibres dexterouſly through, there appear'd in the Microſcope as great a number of ſmall Veſſels running along theſe Fibres, as I had formerly ſeen in the Muſcular Fibres of a Whale.

But what appear'd to me the moſt remarkable, was, that in a great number of Fibres, in which I was not able to diſcover any Veſſels running according to their length, I obſerved abundance of ſmall Veſſels, which ſeemed to me to proceed from the Membranes encompaſſing the Fibres. For in one Fibre theſe Veſſels appear'd to come out of the Circumference, or circular Tunicle of the Fibre, and to paſs on to the oppoſite part of the Tunicle. And in another Fibre cut tranſverſly, I ſaw Veſſels ariſing from the Circumference, and dividing themſelves into ſmaller Branches about the middle of the Fibre; all which, as far as I could perceive, ended again in the Circumference of the Fibre. In one Fibre I ſaw at leaſt fifty of theſe Veſſels running through one another.

Upon this Diſcovery, I found I had been miſtaken in what I had at firſt imagin'd, which was, that the Veſſels, which aroſe from the Membranes, proceeded no farther, than juſt through the Tunicle of the Fibre, and ſo diſcharged the Fluid into the Fibre for its Nouriſhment. Whereas, now I perceiv'd, that the Veſſels, which aroſe from the Membrane, and entred into the Fibre, did not end there, but ſpread themſelves into ſmaller Branches proceeding every way from the inſide to the Tunicle of the Fibre. This caus'd me to think, that the nutritious Juice might circulate in theſe ſmall Veſſels, juſt as the Blood does in the Veins and Arteries; and that what the Muſcular Fibres received from them, might be no more than what ouzed thro' the Tunicles of theſe ſmall Veſſels, as I have ſaid of the ſmall Veſſels in Land-Animals, which have no other end than the Artery coming from the Heart, and the Vein terminating in the Heart; the Artery and Vein thus making one continued Veſſel.

Having now a great number of Fibres lying before me, in which I could ſee very plainly the Veſſels juſt now treated of, yet I could not diſcern in the tranſverſe Sections of the Fibres any appearance of thoſe Veſſels, which run along their length, and compoſe the greateſt Part of the Body of each Fibre. This I imputed to the cutting of thoſe Veſſels not directly acroſs, but ſomething obliquely, by which their Apertures had been clos'd in ſuch a manner, that I could not perceive them, nor the leaſt Reſemblance of them.

I have ſeveral times obſerv'd, between the Muſcular Fibres of the Fiſh, a great number of Veſſels lying together, which compos'd what is commonly call'd a Membrane, which Veſſels ſurrounded the Muſcular Fibres, and lay ſo many of them together, that the thickneſs of the whole *Faſciculus* of Veſſels was equal to that of a Muſcular Fibre, and, as I imagin'd, was afterwards to be diſpers'd in ſmaller Ramifications between the Fibres.

In taking a View of an entire Muſcle of a Cod-fiſh, and the Fibres of which it was compos'd, I found the thick end of the Muſcle to equal the Back of an ordinary Knife, and the thinner end not to exceed the thickneſs of a ſingle Fibre. Many of theſe Fibres are twice as long as the thickneſs of the Muſcle, and between the Muſcles lie what are commonly call'd Membranes, which are nothing elſe but a *Congeries* of Veſſels. Theſe Veſſels do not only run between the Fibres, but into the very Subſtance of every Fibre, as we ſee, when the Fibres are cut tranſverſly. By theſe Veſſels the Muſcular Fibres, and the entire Muſcles themſelves are ſo firmly bound together, that they ſerve inſtead of Tendons to one another.

In like manner the Muſcular Fibres are united to the Bones, by the Veſſels proceeding from the Bones, which Veſſels compoſe what in Land-Animals is called the *Perioſteum*.

In order to give a clear notion of what I mean, when I ſpeak of the Muſcles of a Cod-fiſh, I have here caus'd two of thoſe Muſcles to be delineated, lying cloſe together, as they are united to one another, and ſeparated from the other Muſcles, as is repreſented by *A*, *B*, *C*, *D*, Fig. 1. the Part deſign'd by *A*, *B*, *C*, having been cover'd with the Skin near the Head of the Fiſh. And it is my Opinion, that the Body of the Cod-fiſh, from Head to Tail, conſiſts of a continued *Series* of ſuch Muſcles.

I have likewiſe caus'd a ſingle Muſcle of the Fiſh to be repreſented by *E*, *F*, *G*, *H*, Fig. 2. where *E*, *H*, *G*, ſhews the Thickneſs of the Muſcle; and its thin Edge, which is no thicker than the Edge of a Knife, is marked by *E*, *F*, *G*.

When theſe Muſcles had lain ſeveral days upon a Paper, yet they were not dry'd ſo hard, but that I could ſplit them into thin Shivers, one of which is deſign'd in Fig. 3. between the Letters *I* and *K*, in order to ſhew the oblique Courſe of the Fibres, which are repreſented by ſmall Lines.

I now turn'd my Thoughts to the River-Fiſh, and particularly to the Pearch; and, as I imagin'd that an old Pearch had no greater number of Muſcular Fibres than a young one, but only that the Fibres encreas'd in bigneſs during the Growth of the Fiſh, and that the larger theſe Fibres were, the more plain and diſtinct muſt be the ſmall Veſſels, of which the Fibres were compoſed; I ſent orders, upon a Market-day, to bring me the largeſt Pearch that was to be found in the Market; and accordingly, I had one brought me the largeſt that I had ever ſeen, weighing three pounds and an half, and ſeventeen Inches and an half in length *Delft* Meaſure, which is the ſame with the *Rhinland*.

I cut off four pieces from this Fiſh, as two from the Back near the Head, and two others from the Belly in the thick part of the Fiſh, with deſign to make my Obſervations upon them the next Day.

Accordingly, at that time, I took a view of the Muſcular Fibres both in length and breadth, and found that the Fibres of this great Pearch were not ſo thick as thoſe of the Cod-fiſh. Upon cutting them thro' lengthwiſe, I ſaw the Apertures of the ſmall Veſſels in ſo great a number, as I could hardly have believ'd, if I had not ſeen them. I next cut ſome of the Fibres tranſverſly, and plainly found them thinner in this Pearch, than in a middling Cod-fiſh, and ſaw the ſmall Veſſels,that compoſe the greateſt part of the Bulk of the Fibre, lying as cloſe together, as ever I ſaw them in any kind of Fiſh or Fleſh.

To give a better notion of theſe Muſcular Fibres, and of the great number of ſmall Veſſels,of which they are chiefly compos'd; I had,ſome Weeks before,placed ſome of them cut tranſverſly in pieces before a Microſcope, with deſign to have them drawn by my Painter, but had been obliged to defer it,by reaſon of the great Severity of the Weather. Theſe had been a little moiſtned before they were placed upon the Glaſs, in order to make them ſtick to it the better; and I have cauſed a ſmall portion of theſe Muſcular Fibres of the Fiſh, cut thro' tranſverſly, after they were grown dry, and in their ſhrinking had been torn off from the ſmall Veſſels, that encompaſt them, to be repreſented, as at *L*, *M*, *N*, *O*, Fig. 4. The openings of the ſmall Veſſels in theſe Fibres were diſtinctly to be ſeen, but appeared in ſuch great numbers, and were ſo exceedingly ſmall, that it was impoſſible for the Painter to repreſent them any otherwiſe than by Points.

In this Figure are repreſented what we call the Membranes, but which indeed are nothing elſe but a *Congeries* of ſmall Veſſels, which not only ſurround the Fibres, but enter into their very Subſtance. Theſe, in the drying and ſhrinking of the Object upon the Plate, had been torn off from the Fibres, as may be ſeen at *P*, *P*, *P*.

When this was done, I put a ſmall Drop of Water, about the ſize of a Pin's head, on this ſmall Portion of Fibres, into which it immediately inſinuated and ſwell'd them to the ſame bigneſs, as when they were firſt laid upon the Plate: After which, I deſir'd the Painter to draw them, as they then appear'd to him, but to omit repreſenting the ſmall Veſſels, and only to deſign the Circumference of every Fibre, which he did, as appears at *Q*, *R*, *S*, *T*, Fig. 5.

I then clove a grain of Millet thro' the middle, and placing one half of it upon the Glaſs, beſide the portion of Fibres repreſented in Fig. 4. I deſir'd the Painter to obſerve the difference in bigneſs between the half grain of Millet-ſeed, and that portion of Fibres; who told me, that the half grain appear'd larger than the portion of Fibres, and ſo ſaid likewiſe a ſecond Perſon that view'd them. By which one may eaſily imagine, in how ſmall a ſpace that number of Fibres is comprehended, each of which conſiſts of ſo many Veſſels. I caus'd the Painter to repreſent the half grain of Millet at Fig. 6.

I likewiſe made my Obſervations upon the Muſcular Fibres of a Pike, a Roach, Schar, and Flounder,

in

in each of which I found the Fibres to be compoſed of ſmall Veſſels, like thoſe of a Cod and Pearch.

I had now a mind to examine the Muſcular Fibres of the Smelt, to ſee whether they were likewiſe compoſed of Veſſels, but not being able at that time to meet with any Smelts, it came into my Head to obſerve the ſame in dried Sprats. Accordingly I took the largeſt of theſe I could light on, which was a little more than five Inches in length, and I found that the Fibres of the Sprat were but little thinner than thoſe of the large Pearch ſpoken of before, and that the Veſſels of which the Fibres were compoſed, were nearly as numerous as in the Fibres of the Pearch.

From theſe Obſervations ſome Perſons may be apt to conclude, that the Muſcular Fibres of Land-Animals are of the ſame thickneſs with thoſe of Fiſh. But for the ſatisfaction of thoſe, who have not ſeen the Objects here ſpoken of, I have cauſed a ſmall portion of the Muſcular Fibres of a large Ox to be delineated, as they appear'd through the ſame Microſcope with the former, to ſhew the thickneſs of the dried Fibres, and the Veſſels that compoſe them, as is repreſented in *Fig.* 7. by *XYZ.*

I deſir'd the Painter to tell me, how many Veſſels he could ſee in the tranſverſe Section of one of theſe Fibres; who, after ſome pauſe, reply'd, That he counted five and twenty Veſſels in one Fibre.

Some time after this, I had a ſmall Smelt brought me, of the length of about two Joints of my Finger; and cutting ſome of its Muſcular Fibres tranſverſly, I placed them before a Microſcope, and ſaw not only that theſe Fibres were twice as thick as thoſe of an Ox, but likewiſe that they were provided with as great a number of Veſſels as the Fibres of other Fiſh.

Upon thus obſerving that the muſcular Fibres of Fiſhes were much larger than thoſe of Beaſts, I ſet my ſelf to conſider, for what Reaſons the great Creator of the Univerſe had made this Diſproportion between them. All the Satisfaction I could meet with, in my Thoughts upon this Subject was that, as the Fiſh ſwim in the Water, their muſcular Fibres need to exert very little force, in order to ſupport their Bodies in the Water, becauſe they are very nearly of the ſame ſpecifick Gravity with the Element, in which they ſwim. All the force they exert is in their progreſſive Motion, in purſuit of their Food. Whereas the muſcular Fibres of Land-Animals exerciſe a great force, not only in ſupporting and moving their own Bodies, but in carrying Burthens and other Labour they are put to. And we muſt allow, that the ſmaller and finer the Fibres are, to make a Body of any determinate thickneſs, the ſtronger will be the Compoſition, and therefore the Muſcles in Fleſh muſt be ſtronger than thoſe of Fiſh. But this I leave to better Judgments.

It juſtly claims our Admiration, to ſee the wonderful and amazing Structure of theſe minute Parts in the Muſcles of Beaſts and Fiſh, which never enter'd into our Thoughts; and no doubt there are many other ſurpriſing things there incloſed, which will perhaps for ever eſcape our Penetration.

I am, &c.

P. S.

I Happen'd yeſterday to take up a boil'd Grey Pea, out of which I took a little of the mealy Subſtance, and laid it before a Microſcope, where it appear'd to conſiſt of ſuch like Parts as are found in Rats Dung, every one of which Parts conſiſted of a great number of very ſmall Particles. But I could not diſcover any Membranes enveloping thoſe Parts, from whence I concluded, that thoſe Membranes were deſtroy'd and diſſolv'd by the hot Water.

Upon this, I took another Grey Pea, which had not been boil'd, and cut it into very thin Slices, when I not only ſaw the Membranes, in which the Parts of the mealy Subſtance had been incloſed, but found likewiſe, that thoſe Membranes conſiſted of nothing elſe but a great number of very ſmall Veſſels, like the Membranes, as they are commonly call'd, which ſurround the Muſcles and muſcular Fibres in Beaſts and Fiſh.

I intend to proſecute this Subject farther for my own Diverſion.

Philoſoph: Tranſact: N° 368

Fig: 1.

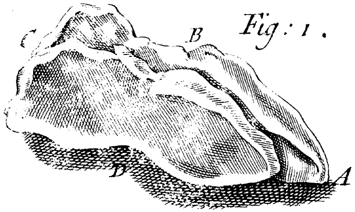

Fig: 2.

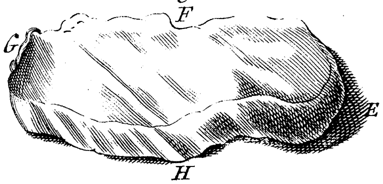

Fig: 3.

Fig: 4.

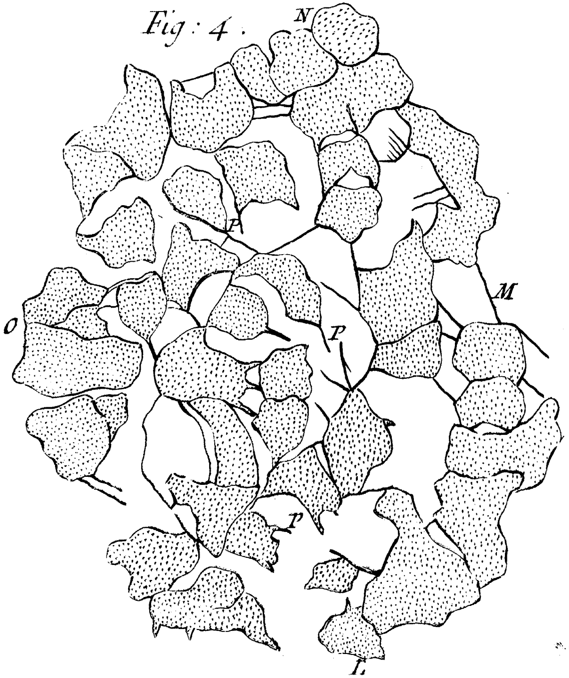

Fig: 5.

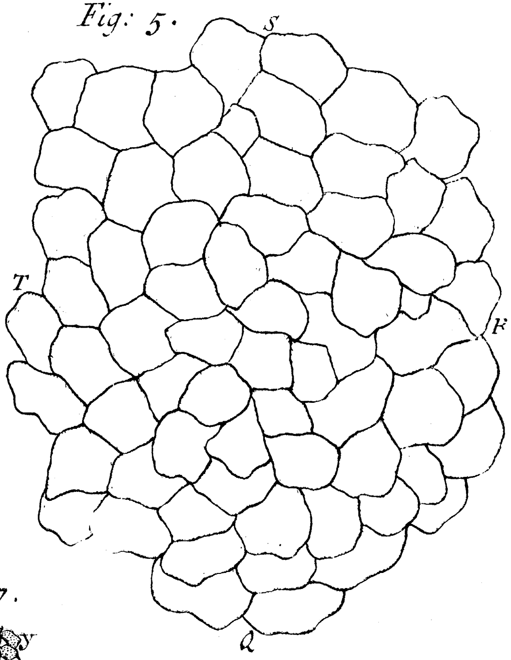

Fig: 7.

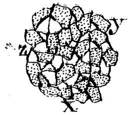

Fig: 6.